MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2017/2018

DET5038 – POWER ELECTRONICS

(Diploma in Electronics Engineering)

4 JUNE 2018
9:00 AM –11:00 AM
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **8** pages (**6** pages with **5** questions and **2** pages for appendix).

2. Answer ALL questions. All necessary working steps must be shown.

3. Write all your answers in the answer booklet provided.

QUESTION 1 [20 marks]

(a) Compare MOSFET and BJT characteristic in terms of:

(i) Trigger method to switch ON the device

(2 marks)

(ii) Switching speed

(2 marks)

(iii) On state voltage drop

(2 marks)

(iv) Blocking voltage

(2 marks)

(v) Temperature coefficient of on-state resistance

(2 marks)

(b) Briefly explain the term commutation.

(2 marks)

(c) Draw a circuit of a Single Phase Full Wave Bridge Rectifier with Resistive Load. Label all the components and power supply.

(4 marks)

(d) For the circuit in (c), sketch the waveform of a circuit covering the parameter of input voltage Vs(t), input current $i_s(t)$, output voltage $V_o(t)$ and output current $i_o(t)$.

(4 marks)

Continued ...

QUESTION 2 [20 marks]

(a) Draw the schematic diagram of a Buck DC-DC Converter, a Boost DC-DC Converter and a Buck-Boost DC-DC Converter. State the main function for each types of the converters.

(9 marks)

(b) State the three functions of a Pulse Width Modulator (PWM).

(6 marks)

(c) Figure 1 shows a resonant converter. Sketch the equivalent circuit for all three modes of the circuit's operation.

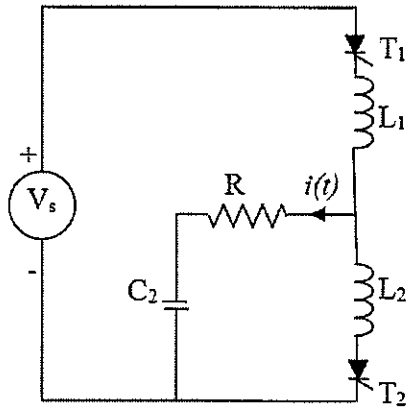


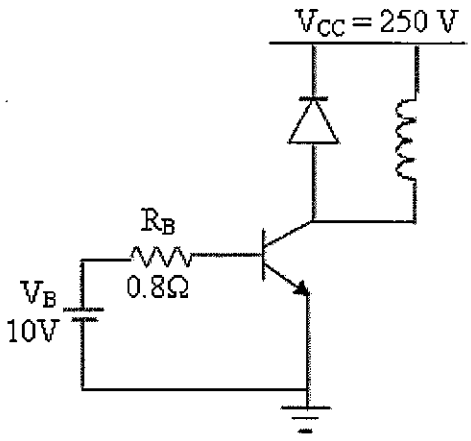
Figure 1

(5 marks)

Continued ...

QUESTION 3 [20 marks]

A power BJT is used to switch an inductive load across a 250 V supply at 80 Hz, as shown in Figure 2. The transistor operates at 80% of duty cycle and the inductance of the load is large so that the load current is constant with a value of 5 A.



$V_{CE(max)} = 250$ V

$V_{CE(sat)} = 0.5$ V

$V_{BE(on)} = 0.7$ V

$I_{C(leak)} = 5$ uA

$\beta = 20$

$\tau_{on} = 150 \ \mu s$

$\tau_{off} = 200 \ \mu s$

Figure 2

By neglecting the on state voltage drop across the diode, calculate the following:

(a) t_{on} and t_{off}

(9 marks)

(b) P_{static}

(7 marks)

(c) $P_{dynamic}$

(3 marks)

(d) P_{TOTAL}

(1 mark)

Continued ...

QUESTION 4 [20 marks]

(a) A single phase full wave uncontrolled rectifier is connected to a 190 Ω resistor. If the circuit is operated from a 250 V, 50 Hz supply, calculate the following:

(i) Average output voltage.

(2 marks)

(ii) RMS output voltage.

(2 marks)

(iii) Ripple voltage.

(2 marks)

(iv) Ripple voltage factor.

(2 marks)

(v) Average output current.

(2 marks)

(b) A buck-boost converter generates an output voltage of 48 V across a 20 Ω resistor from an input voltage of 12 V. The output ripple voltage must be less than 1 V at a switching frequency of 1500 Hz under continuous conduction mode. Determine the following parameters:

(i) The input and output power.

(4 marks)

(ii) The duty ratio.

(2 marks)

(iii) The inductance value.

(2 marks)

(iv) The capacitance value.

(2 marks)

Continued ...

QUESTION 5 [20 marks]

(a) Calculate the following for the single-phase half-bridge inverter which, has a DC input voltage of $V_s = 888 \ V$.

(i) The RMS output voltage of the fundamental component.

(1 mark)

(ii) The RMS output voltage.

(1 mark)

(iii) The RMS output voltage of total harmonic component.

(2 marks)

(iv) The harmonic factor of the 1st, 2nd and 3rd harmonic.

(2 marks)

(v) The total harmonic distortion.

(2 marks)

(vi) The voltage transfer ratio.

(2 marks)

Continued ...

(b) Figure 3 shows a resonant inverter circuit. It is operating at an output frequency of 8 kHz. The circuit turn off time is given as 45 μs.

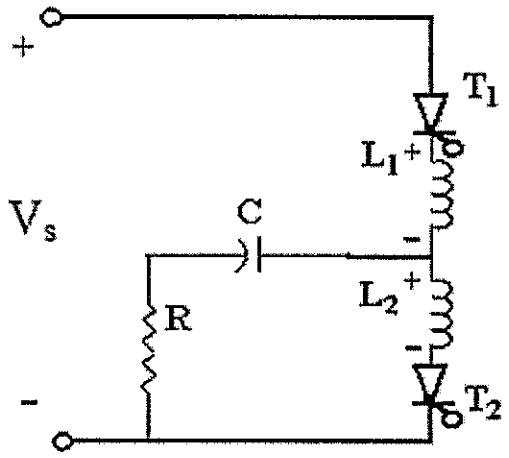


Figure 3

Assume that the circuit turn off time is nine times longer than the thyristor turn off time, determine the maximum permissible frequency, f_{max}.

(10 marks)

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APPENDIX

Table 1 Switching power loss of power BJT

	Resistive Load	Inductive Load
ON state	$P_{on} = [V_{CE(sat)} I_{C(on)} + V_{BE(on)} I_{B(on)}] \frac{t_{on}}{T}$	$P_{on} = [V_{CE(sat)} I_{C(on)} + V_{BE(on)} I_{B(on)}] \frac{t_{on}}{T}$
OFF state	$P_{off} = [V_{CC} I_{C(leak)}] \frac{t_{off}}{T}$	$P_{off} = [V_{CC} I_{C(leak)}] \frac{t_{off}}{T}$
Turn On	$P_{turn-on} = V_{CC} I_{C(on)} \frac{\tau_{on}}{6T}$	$P_{turn-on} = V_{CC} I_{C(on)} \frac{\tau_{on}}{2T}$
Turn Off	$P_{turn-off} = V_{CC} I_{C(on)} \frac{\tau_{off}}{6T}$	$P_{turn-off} = V_{CC} I_{C(on)} \frac{\tau_{off}}{2T}$

Table 2 Switching power loss of power MOSFET

	Resistive Load	Inductive Load
ON state	$P_{on} = I^2_{D(on)} R_{DS(on)} \frac{t_{on}}{T}$	$P_{on} = I^2_{D(on)} R_{DS(on)} \frac{t_{on}}{T}$
OFF state	$P_{off} = I_{D(off)} V_{DD} \frac{t_{off}}{T}$	$P_{off} = I_{D(off)} V_{DD} \frac{t_{off}}{T}$
Turn On	$P_{turn-on} = \frac{V_{DD} I_{D(on)} \tau_{on}}{6T}$	$P_{turn-on} = \frac{V_{DD} I_{D(on)} \tau_{on}}{2T}$
Turn Off	$P_{turn-off} = \frac{V_{DD} I_{D(on)} \tau_{off}}{6T}$	$P_{turn-off} = \frac{V_{DD} I_{D(on)} \tau_{off}}{2T}$

Table 3 Useful equations of DC to DC converters

Buck Converter	Boost Converter	Buck-Boost Converter
$V_o = DV_s$	$D = 1 - \frac{V_s}{V_o}$	$D = \frac{V_O}{V_s + V_O}$
$I_L = \frac{V_o}{R}$ $(\Delta i_L)_{close} = \frac{V_s - V_o}{L} DT$ $(\Delta i_L)_{open} = -\frac{V_o}{L}(1-D)T$	$I_L = \frac{V_s}{R(1-D)^2}$ $(\Delta i_L)_{close} = \frac{V_s}{L} DT$ $(\Delta i_L)_{open} = \frac{V_S - V_o}{L}(1-D)T$	$I_L = \frac{V_s D}{R(1-D)^2}$ $(\Delta i_L)_{close} = \frac{V_S}{L} DT$ $(\Delta i_L)_{open} = -\frac{V_o}{L}(1-D)T$
$L = \frac{(1-D)R}{2f}$	$L = \frac{D(1-D)^2 R}{2f}$	$L = \frac{(1-D)^2 R}{2f}$
$C_{min} = \frac{1-D}{8Lf^2 \frac{\Delta V_o}{V_o}}$	$C = \frac{D}{Rf \frac{\Delta V_o}{V_o}}$	$C = \frac{D}{Rf \frac{\Delta V_o}{V_o}}$